LORING AIR FORCE BASE, ARCH HANGAR
(Loring Air Force Base, Building 8250)
East of Arizona Road, near the southern
end of runway
Limestone Vicinity
Aroostook County
Maine

HAER No. ME-64-B

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Northeast Region
Philadelphia Support Office
U.S. Custom House
200 Chestnut Street
Philadelphia, Pennsylvania 19106

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HISTORIC AMERICAN ENGINEERING RECORD

LORING AIR FORCE BASE, ARCH HANGAR
(Loring Air Force Base, Building 8250)

HAER NO. ME-64-B

Location:

East of Arizona Road, near the southern end of runway
Limestone Vicinity
Aroostook County, Maine

USGS 7.5-minute Fort Fairfield NW Quadrangle
Universal Transverse Mercator Coordinates:
19:584292.5198866

Date(s) of Construction:

1947-1949

Architect:

Roberts and Schaefer Company

Contractors:

Lane Construction
T.W. Cunningham, Inc.

Present Owner(s):

United States Air Force
Air Force Base Conversion Agency (AFBCA) – Loring
RR 1, Box 1719
Limestone, Maine 04750-7943

Present Occupants:

Vacant

Present Use:

Vacant

Significance:

The Arch Hangar at Loring Air Force Base (AFB) was one of the first structures specifically built as an element of the Strategic Air Command (SAC) mission of deterring the enemy through retaliatory strike capability. The first hangar completed at Loring AFB, it was an integral part of the early aircraft maintenance system and was built in response to the demand for efficient aircraft service facilities. The Arch Hangar was one of two structures simultaneously built as the largest monolithic arch roof structures up to that time in the United States. The hangar contained several unique construction features including the foundation set on bedrock, the extensive column-on-pedestal-on-footing abutment construction, the intricate formwork required, the elaborate system of rail and jacks required to move the formwork, the thinness of the concrete slab roof, and the 340-foot span of the arch.

Project Information:

Pursuant to the recommendations of the 1990 Defense Base Closure and Realignment Commission, Loring AFB was closed in September 1994. In order to mitigate adverse effects to historic properties that may occur with conveyance of property to a non-federal agency, mitigation measures were recommended in the Loring AFB Historic Building Inventory and Evaluation. The Maine State Historic Preservation Officer (SHPO) has concurred with the Air Force's recommendation of Historic American Building Survey (HABS)/Historic American Engineering Record (HAER) recordation of National Register-eligible properties in lieu of nomination to the National Register.

Earth Tech, Inc.
1461 East Cooley Drive, Suite 100
Colton, California 92324

SUMMARY DESCRIPTION OF THE ARCH HANGAR

Historical Background. Construction of the Arch Hangar at Loring Air Force Base (AFB) was begun in September 1947. The hangar was specifically designed to accommodate two B-36 aircraft, at that time the principal Air Force bomber aircraft. The Arch Hangar was designed by the Roberts and Schaefer Company of Chicago (Stevens and Tyson 1980:15). The Roberts and Schaefer Company of Chicago designed the hangar, using what was known as the "Z-D System," in the 1930s in cooperation with the German firm of Dyckerhoff & Widmann (*New York Times* 1994). The Z-D System is characterized by a monolithic concrete span in which only the roof slab is the carrying structure.

The contractors were the Lane Construction Corporation of Meriden, Connecticut, and T.W. Cunningham, Inc., of Bangor, Maine. The project fell under the jurisdiction of the New England Division of the U.S. Army Corps of Engineers (USACE). Brigadier General Raymond G. Moses was the Division Engineer, Army Resident Engineer Robert E. Lee was the construction supervisor, and E.D. Moore was the project engineer. The Arch Hangar was completed in June 1949.

Description and Construction Details. Loring AFB Maintenance Hangar No. 8250, commonly known as the Arch Hangar and originally known as Hangar No. 1, is a monolithic long-span concrete arch structure. The hangar is just east of Arizona Road, near the southern end of the runway. It is west of the runway, Taxiway J (an alternate runway originally called the Alpha Taxiway), and the main hangar apron. A taxiway leads from the main hangar apron on the east to the north and south Arch Hangar access aprons and entrances. The defining characteristic of the hangar is the span of the arch—a width of 340 feet. The arch takes the shape of a reverse catenary and is ribbed on the outside. The hangar is 314 feet long. The hangar ranges in interior height from 16 feet at the spring line, to 90 feet at the crown of the arch.

Due to the short building season for pouring exposed concrete in northern Maine, construction of the superstructure was planned for the spring and summer. With heated enclosures, the substructure of the hangar could progress through the fall and winter, and was begun in September 1947. Due to extreme weather conditions, the hangar footings were set on limestone bedrock at an average depth of 22 feet below floor level. Footings measured 8 feet by 35 feet and reached a maximum height of 7 feet. Battered pedestals set on the footings were as large as 4 feet by 26.5 feet, their height dependent on the elevation of the bedrock. Columns, 3 feet by 14 feet, extended from the pedestals to a point 16 feet above the floor to the spring line of the arch ribs. The columns form the core of the abutment side walls of the hangar. They are tied together at the spring line by a slab and longitudinal beams. The substructure of the hangar was completed in July 1948.

The hangar superstructure is composed of a concrete shell shaped like an inverted catenary that ranges in thickness from 7 inches at the spring line to 5 inches at the crown. The arch is divided by five expansion joints into six 50-foot-long units, each of which is structurally independent.

The shell receives support from reinforced concrete ribs that range from 5 to 7 feet deep and from 20 to 24 inches wide. The ribs are placed 25 feet apart, extend above the shell, and act as compression members. The load of the shell is transferred from the ribs to the columns, then to the pedestals, then to the footings set on bedrock. Each 50-foot section of the arch weighs approximately 1,200 tons, subjecting each column to a dead load thrust of 750 tons at each column (Prentiss 1949:34).

An unusually elaborate formwork system was utilized for the construction of the Arch Hangar. The formwork was built of heavy timber trusses with adjustable trusses near the top. The uppermost layer of the form was a plywood skin in the shape of the hangar. Wheels installed at ground level enabled the formwork to move along tracks the length of the hangar so that the formwork could be reused for each of the six sections of the arch. It was originally intended for the formwork to be reused for additional hangars, but no additional arch hangars were built at Loring AFB. In addition to the tracks, 96 jacks at floor level and 175 jacks under the adjustable truss at the top of the formwork increased the mobility of the formwork.

To place the superstructure concrete, ground-level buckets were hoisted by two cranes to hoppers. The concrete was then transferred to buggies that ran on timber tracks along the arch, then passed through chutes to the specified location. This was considered an improvement over the Rapid City method that utilized elevators instead of cranes. The concrete was set from the spring line to the crown, ribs first.

The first concrete pour was undertaken on 16 and 17 June 1948. It was completed in 27 hours and 36 minutes with two 80-person teams in three shifts. Pours were made approximately every 3 weeks. As the work on the hangar progressed, the pour time was reduced to 15 hours and 20 minutes. The final pour was completed on 29 September 1948. For insulation, the exterior surface of the arch was finished with a layer of fiberglass and a built-up roofing of asbestos felt and asphalt.

Following completion of the arch, the foundations for the door tracks were set and the concrete floor slab was poured. The center 100 feet of the hangar floor was laid 24 inches thick, a 6-inch increase over adjacent areas that was deemed necessary to support the heavier wheel loads that would normally occur near the center. Radiant heating coils installed throughout the floor supply about 40 percent of the overall heat in the space. Floor construction was completed between September and December 1948.

The identical end walls (north and south elevations) of the hangar are primarily composed of six sets of 40-foot-high insulated steel and glass doors that open to an overall width of 300 feet. The doors slide horizontally on tracks, opening from the middle into pockets positioned at the ends of the end walls. The end pockets rise above the side walls of the hangar. The doors can be fully opened in 4 minutes, providing a clear entrance sidth of 300 feet. Above the center pair of sliding doors is a vertical sliding gate, measuring 50 feet wide and 25 feet high, that accommodates the tails of large aircraft. Both end walls have two pedestrian entrances, each one

set within a larger sliding panel. The end pockets and the wall area above the sliding doors are faced with insulated sheet steel.

The abutment side walls (east and west elevations) of the hangar are 16 feet high. Originally, windows in these walls spanned the area between columns above a brick facing. Three pedestrian entrances with brick surrounds were also provided. The eastern wall retains three glazed bays, including one at the middle and two at the southern end; the others have been filled with brick. Two of the pedestrian entrances on this elevation have been filled and another has been created near the middle. The western side wall has undergone similar alterations. A 1952 addition joins the western wall at its northern end (see below).

The interior of the Arch Hangar is an enormous, unimpeded space. Inside, the arch has a smooth surface and lights are hung from the arched ceiling. The floor is concrete. The concrete block side walls of the hangar are pierced by a number of simple window and door openings that provide light, view, and access to the interior of the maintenance shops that line the side walls. The eastern side wall has a stair that leads to a walkway at the second level. The western side of the hangar has a two-story concrete shop addition at the southern end. This addition has a number of doors and windows; the windows have been altered.

An Aircraft Maintenance and Repair Shops Building addition (8251) was erected outside the northwest corner of the Arch Hangar in 1952. A small corridor joins the northern end of the 68- by 250-foot addition to the main hangar. Constructed of structural steel and faced with corrugated siding, the addition rests on a concrete foundation and has a steel deck roof. It includes machine, welding, blacksmith, sheet metal, fabric, and paint shops. Originally, this addition had large expanses of multipane windows and two corridors that joined the addition to the main hangar. The windows have been replaced with smaller, paired windows and the southern corridor has been removed.

The southern elevation of the addition currently has two overhead sliding doors and one window opening. The western elevation features ten pairs of windows that run the length of the wall. The northern elevation has one paired window and a single window. The eastern elevation has seven window openings, the corridor at the northern end that provides access to the main hangar, and a projecting entrance near the southern end that marks the original location of the second adjoining corridor. A storage shed has been erected in the area between the hangar and the addition.

The Arch Hangar is a monolithic concrete arch structure designed to provide maximum fire resistance and minimum form cost, while meeting the military's space requirements. The hangar was designed to accommodate two B-36 aircraft or six B-29 aircraft. Interior floor space of the hangar totals 106,760 square feet, almost 2.5 acres. The monolithic arch method was chosen for its stability when subjected to bombing, its fireproof construction, its wide clear span, its adequate height, and its economy in erecting identical buildings.

The Arch Hangar was completed on 30 June 1949, having utilized 16,000 cubic yards of concrete at a cost of $2.7 million (Stevens and Tyson 1980:chronology, 22). Loring AFB Real Property Records cite 1952 as the date of completion for the Arch Hangar. This seems unlikely given the construction histories presented in contemporary literature.

SOURCES OF INFORMATION

A. Engineering Drawings

Engineering drawings are kept on file at the Air Force Base Conversion Agency at Loring Air Force Base. Upon conveyance of the base property, the drawings will be kept on file at the Loring Development Authority at 5100 Texas Road, Limestone, Maine.

B. Historic Views

Historic photographs are kept on file at the Air Force Base Conversion Agency at Loring Air Force Base. Upon conveyance of the base property, the photographs will be kept on file at the Loring Development Authority at 5100 Texas Road, Limestone, Maine.

C. Bibliography

New York Times
1994 "Anton Tedesco, 90, an Expert in Uses of Reinforced Concrete," 3 April.

Prentiss, Colonel L.W.
1949 "Thin Concrete Arch Roof Provides 340-Ft. Clear Span for Bomber Hangar." *Civil Engineering*, 19 February.

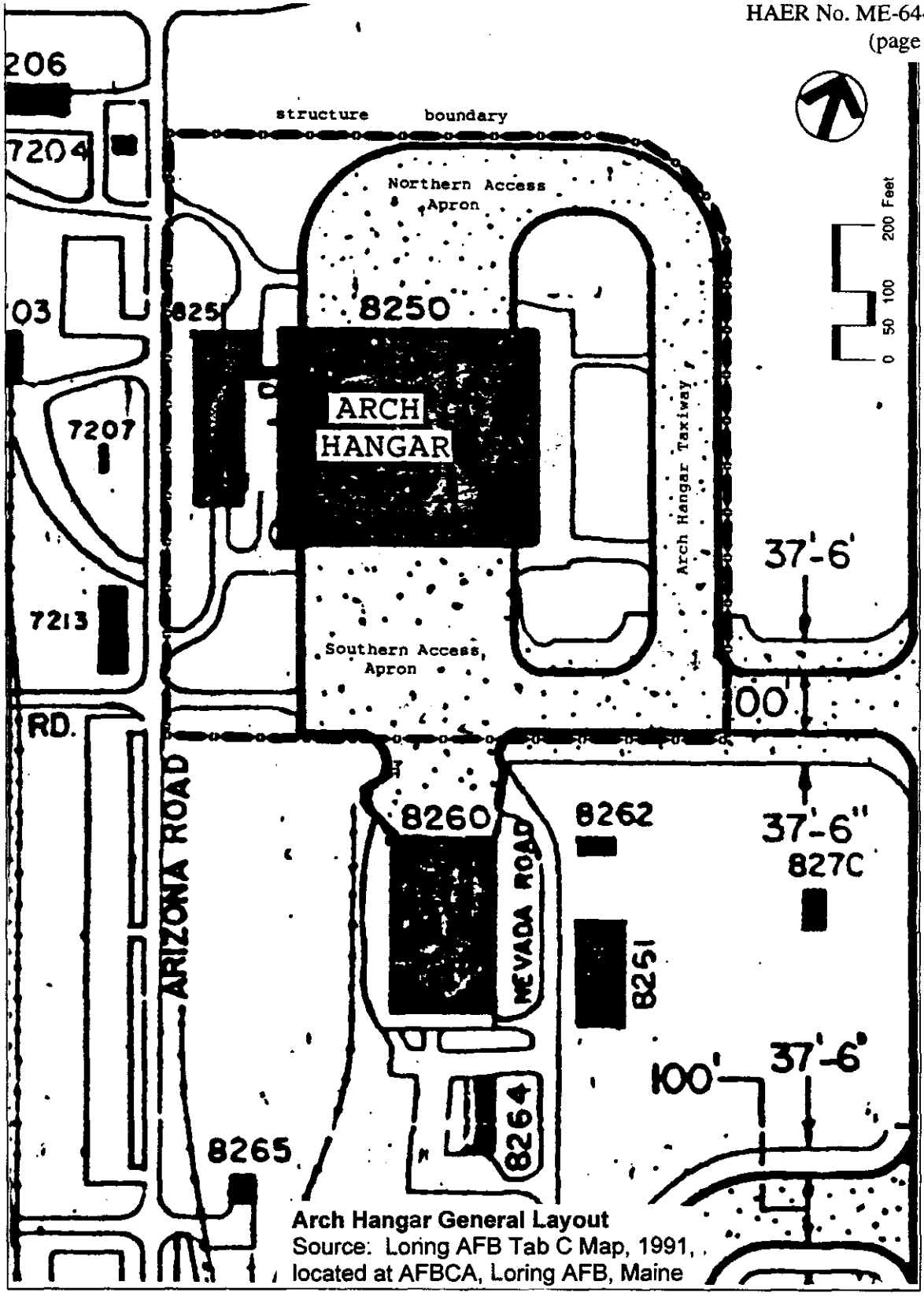
Stevens, W., and P. Tyson.
1980 The Loring Episode. Copy of file, Loring Air Force Base, Limestone, Maine.

U.S. Air Force
1998 *Historic Building Inventory and Evaluation, Loring Air Force Base, Maine.*

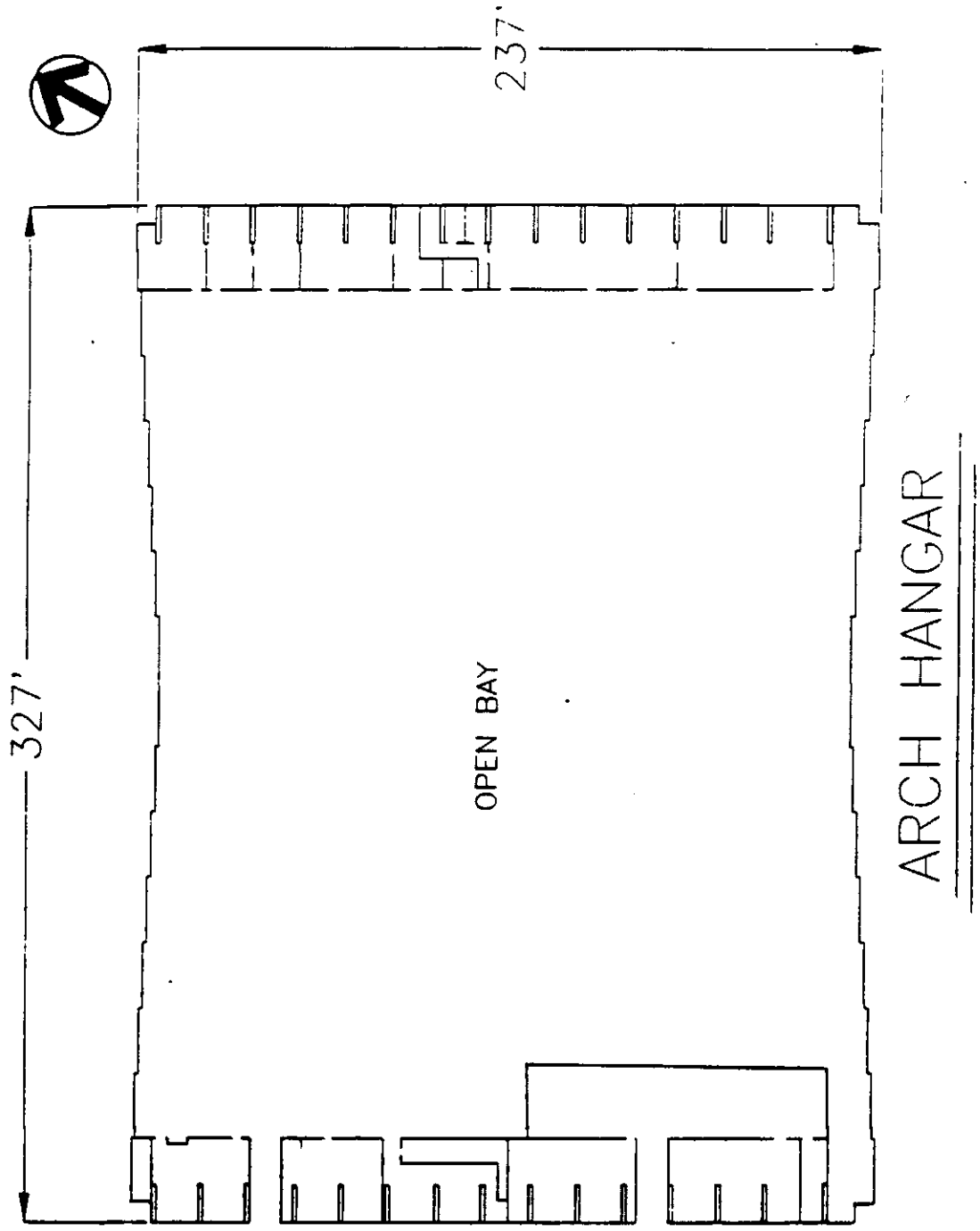
D. Likely Sources Not Yet Investigated

All likely national and local archival sources have been investigated.

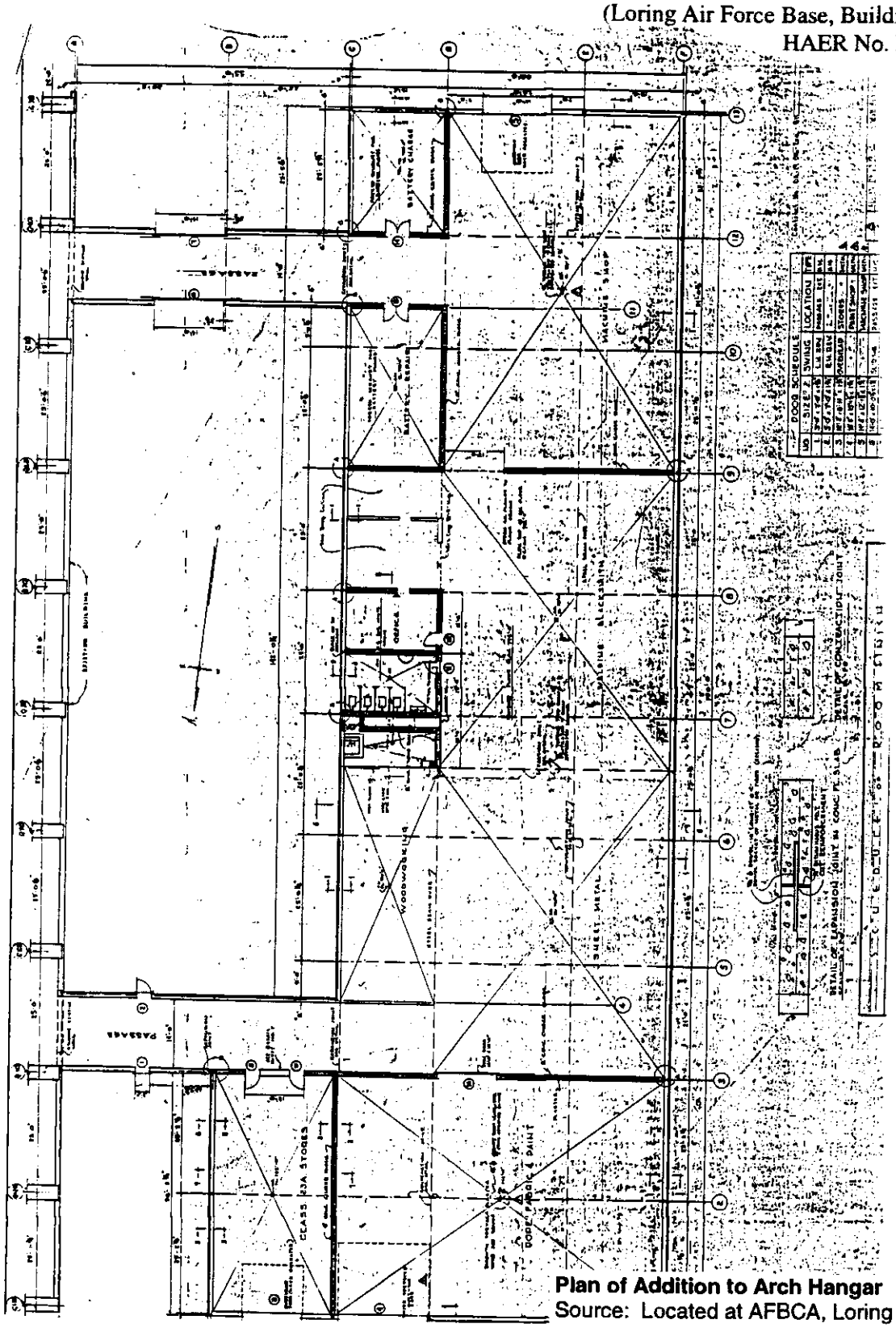
Location of Arch Hangar (Building 8250)
Source: Loring AFB Tab Map, 1993,
located at AFBCA, Loring AFB, Mairie



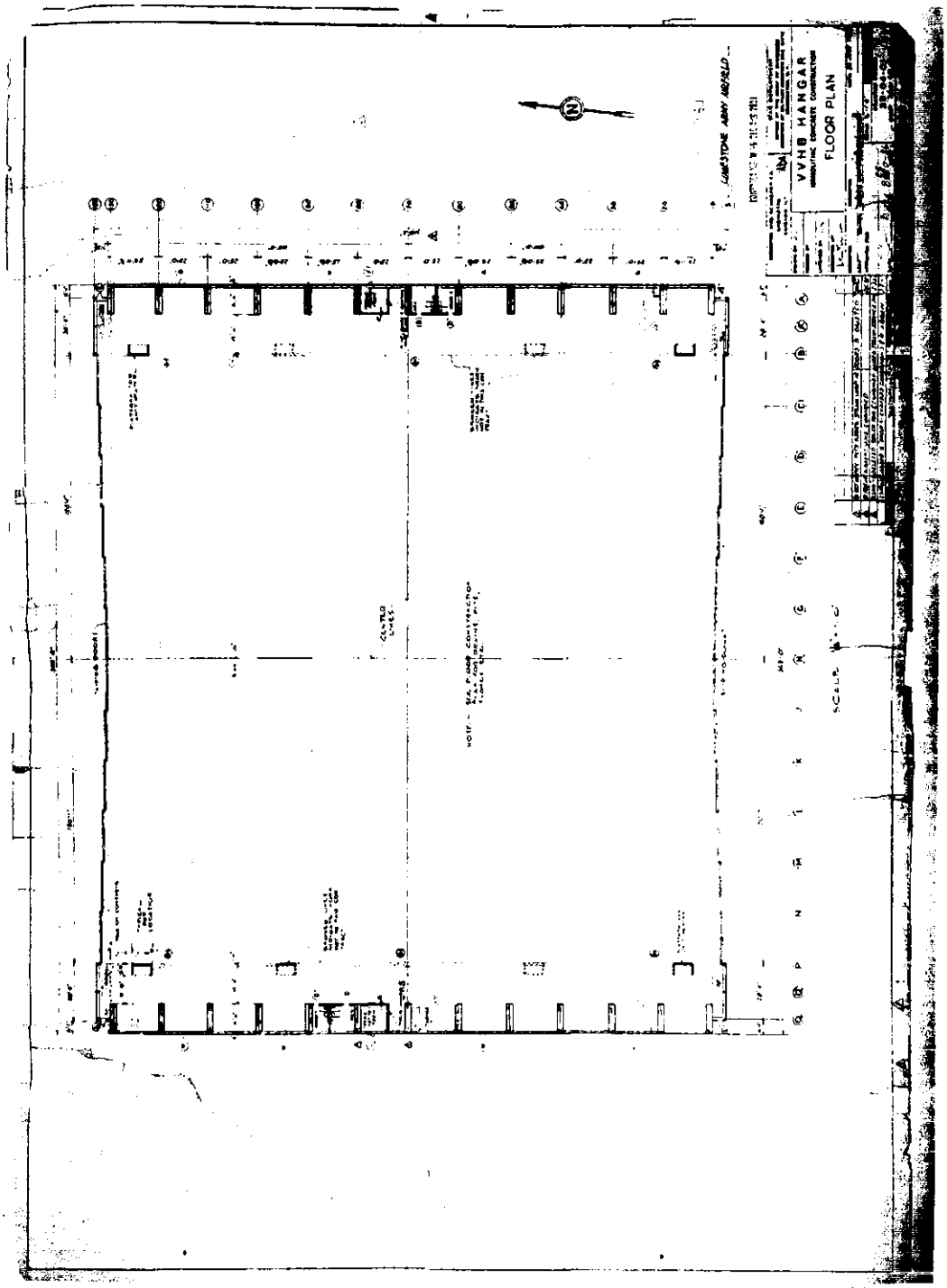
Arch Hangar General Layout
Source: Loring AFB Tab C Map, 1991, .
located at AFBCA, Loring AFB, Maine



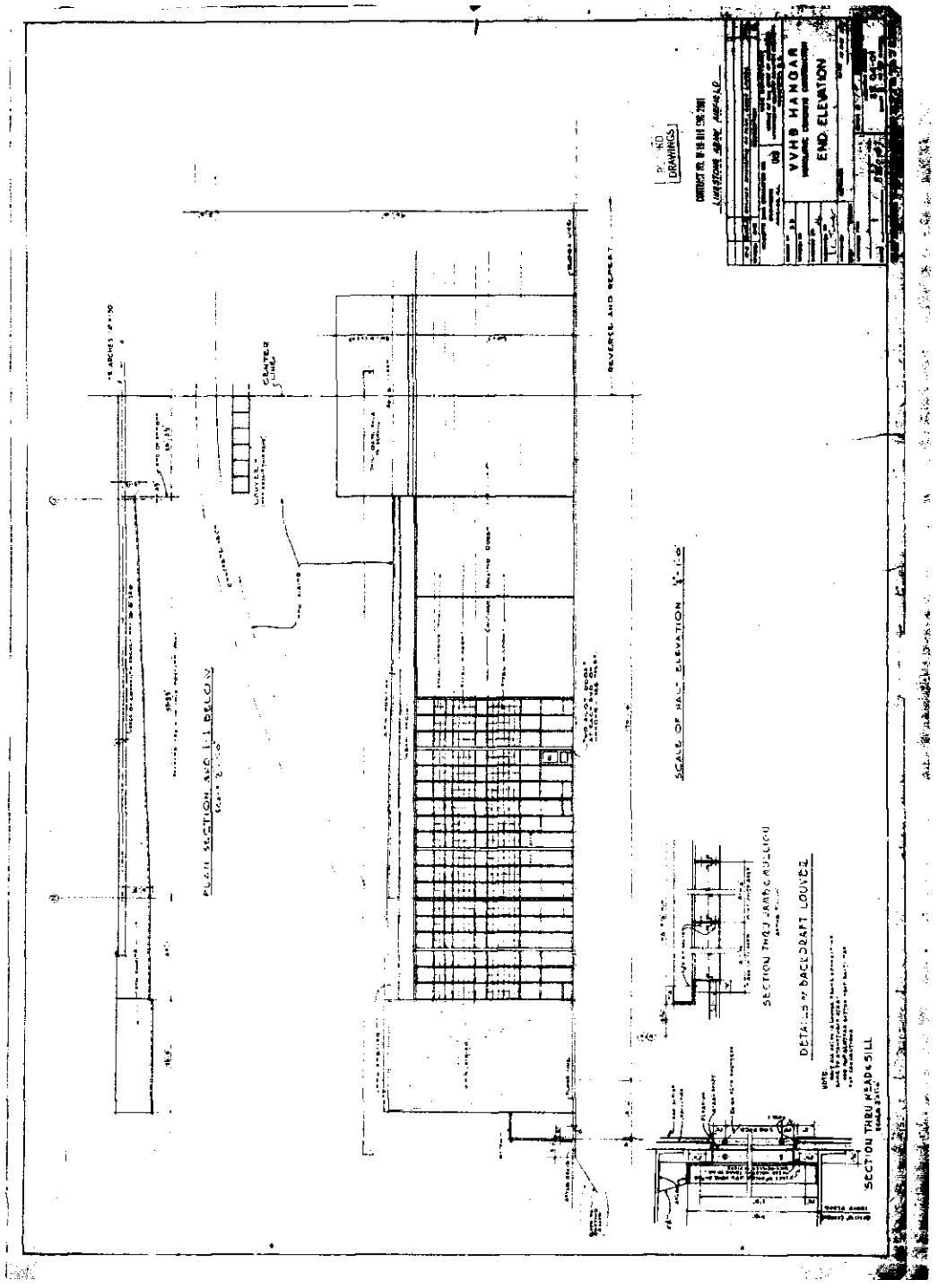
Arch Hangar Floor Plan



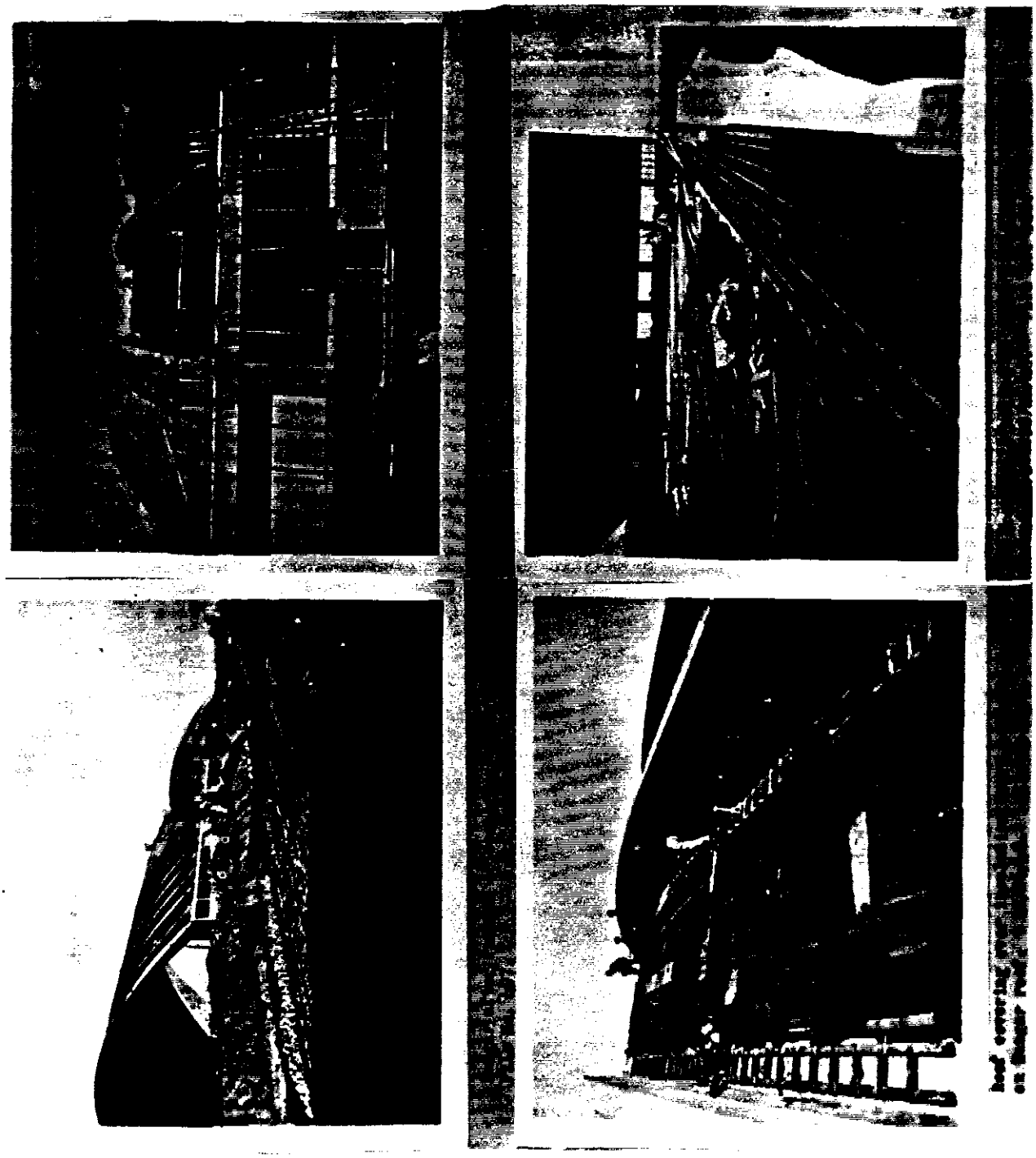
Plan of Addition to Arch Hangar
Source: Located at AFBCA, Loring AFB, Maine



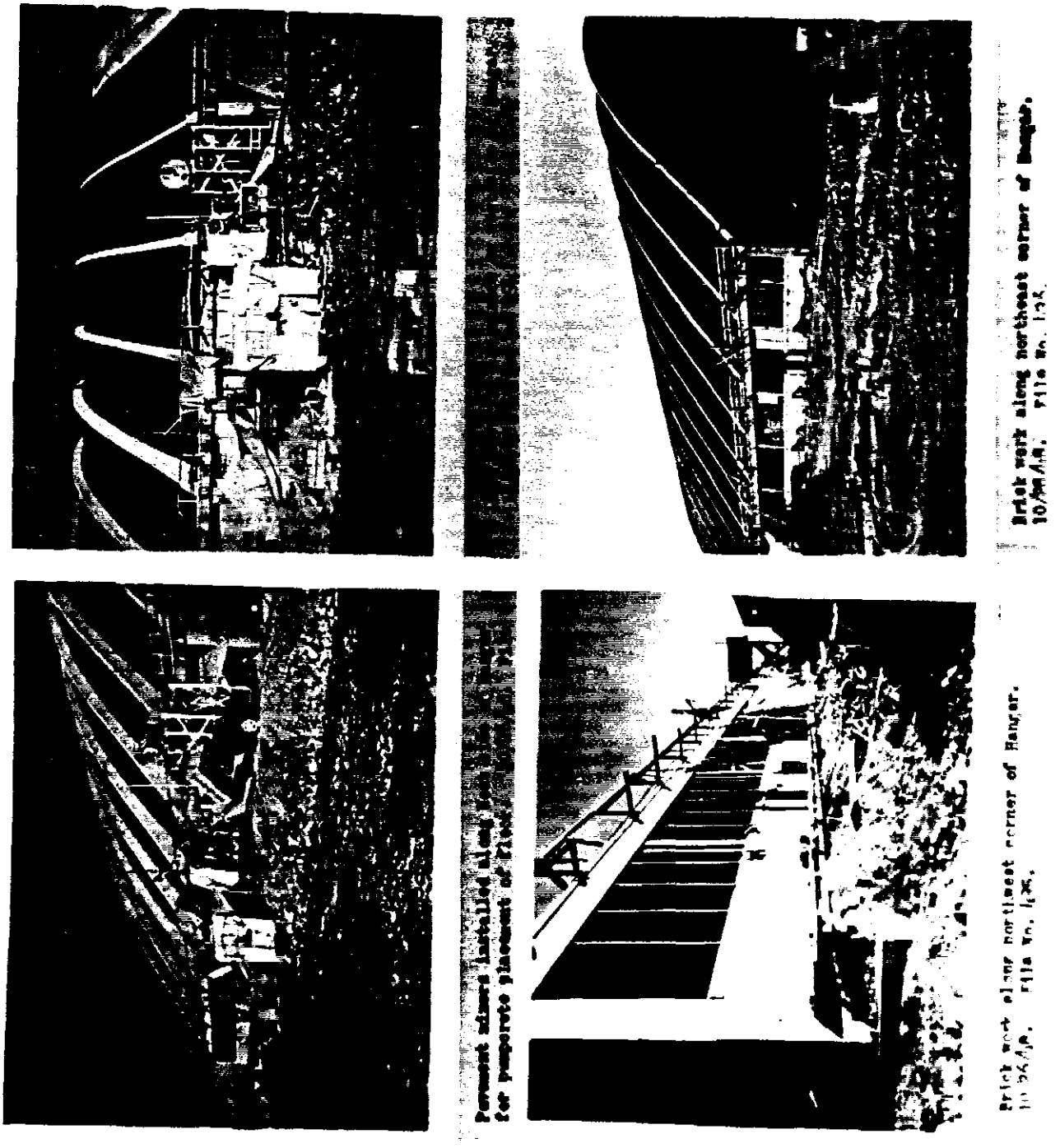
Construction drawing of main floor plan of VVHB Hangar, dated July 22, 1947, with revisions through October 20, 1948. Drawing by Roberts and Schaefer Co. Engineers, located at AFBCA, Loring AFB, Maine.



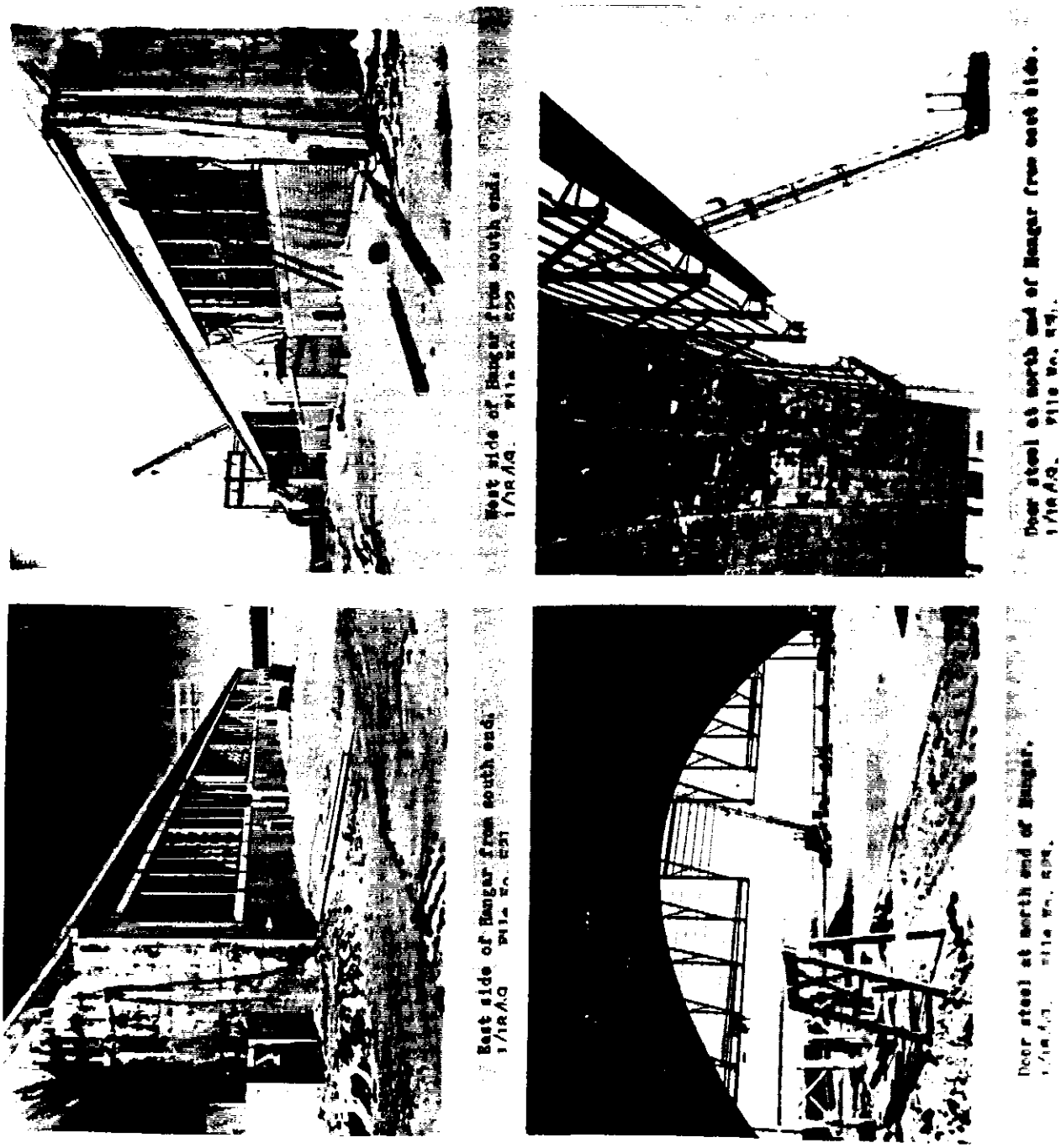
Construction drawing of end elevation (half) of VVHB Hangar, dated May 10, 1947, with revisions dated August 15, 1947. Drawing by Roberts and Schaefer Co. Engineers, located at AFBCA, Loring AFB, Maine.



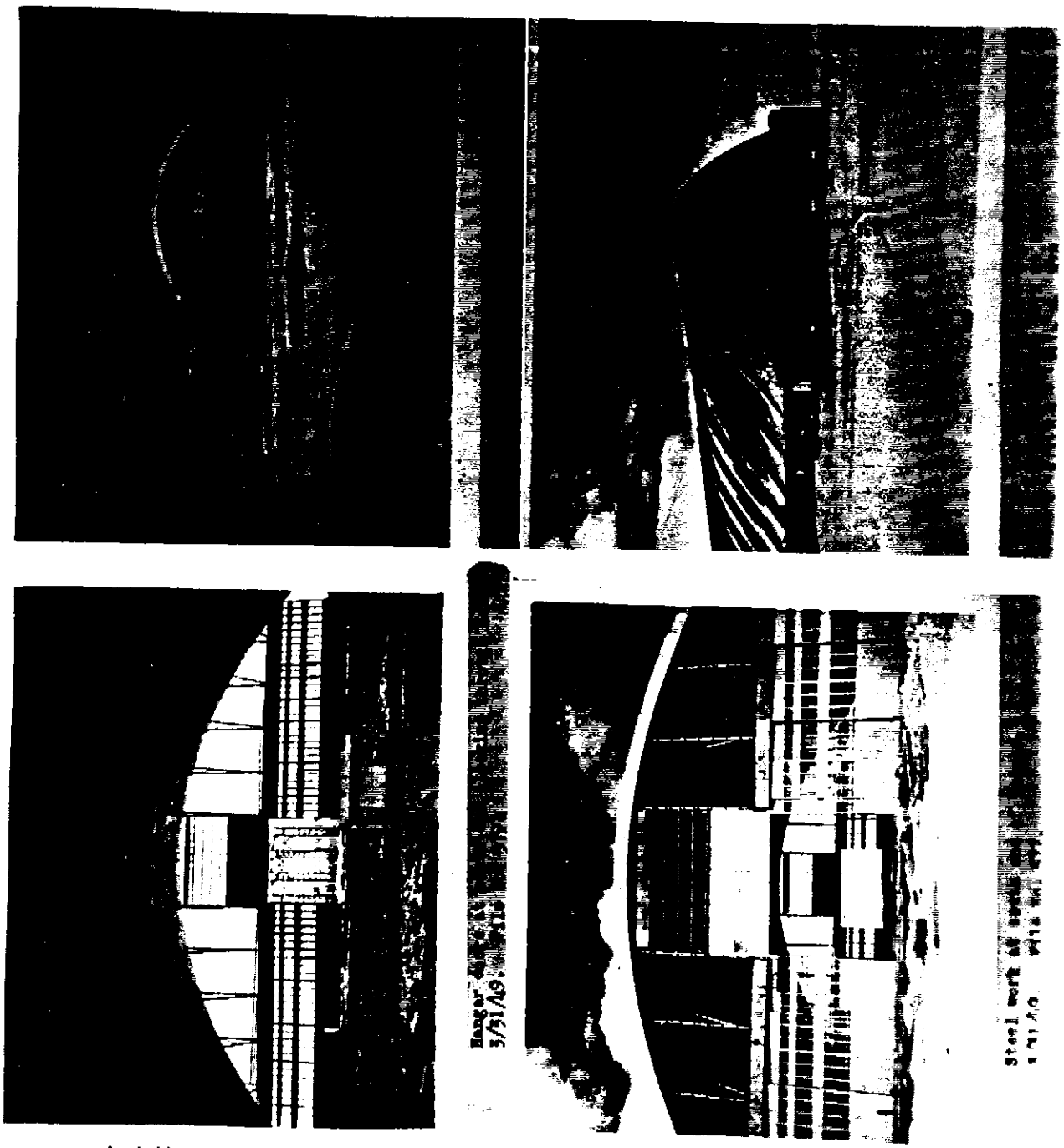
Arch Hangar construction views, with concrete arch, side walls, and door rails, dated October 26, 1948. Photographs located at AFBCA, Loring AFB, Maine.



Arch Hangar construction views, with concrete placement, roof, and side walls, dated October 26, 1948. Photographs located at AFBCA, Loring AFB, Maine.



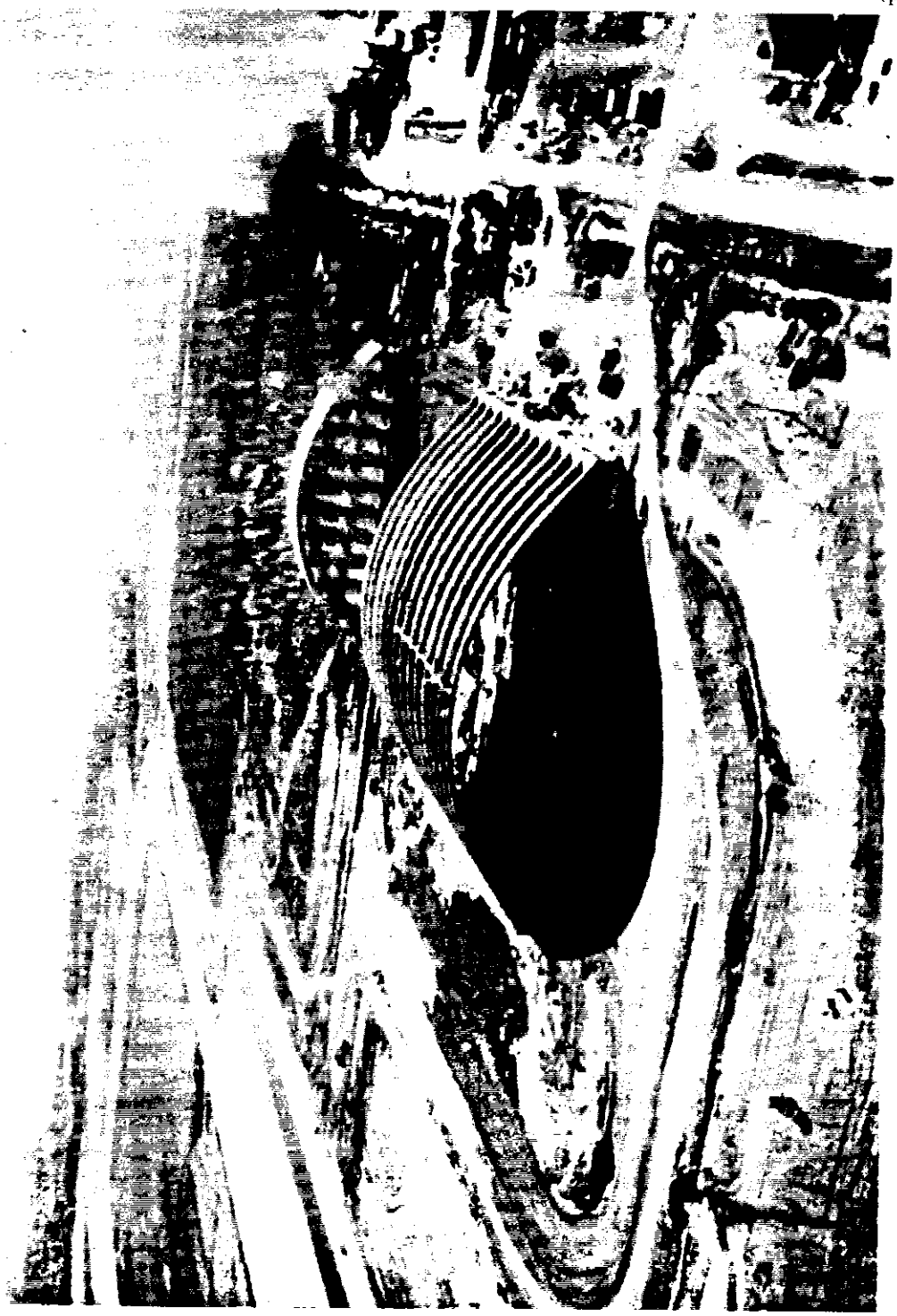
Arch Hangar construction views, with side walls and steel door, dated January 18, 1949. Photographs located at AFBCA, Loring AFB, Maine.



Arch Hangar construction views, with hangar doors and steelwork, dated March 31, 1949. Photographs located at AFBCA, Loring AFB, Maine.

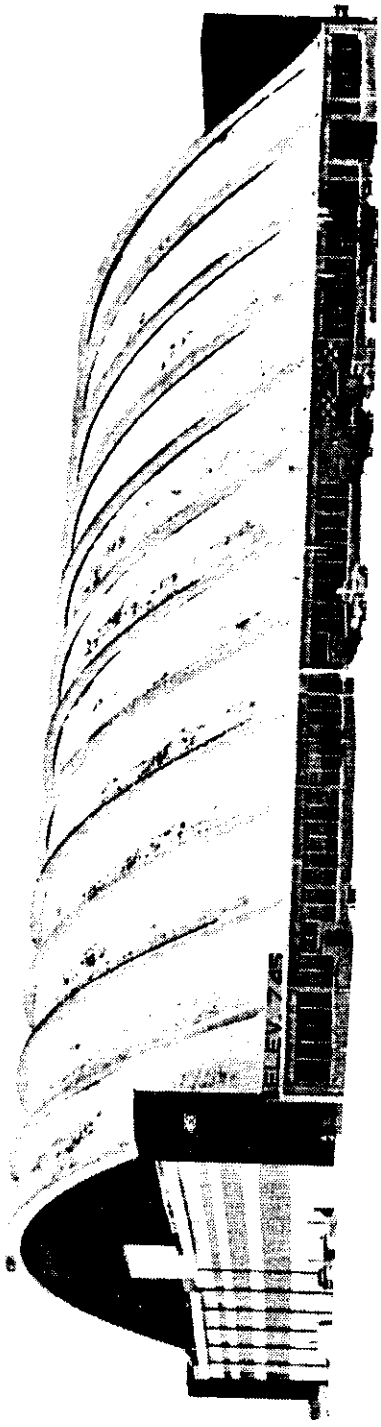
Buggy and runways and hopper arrangement for hangar arch pour, dated June 16, 1948. Photograph located at AFBCA, Loring AFB, Maine.

Arch hangar under construction, circa 1948. Photograph located at AFBCA, Loring AFB, Maine.

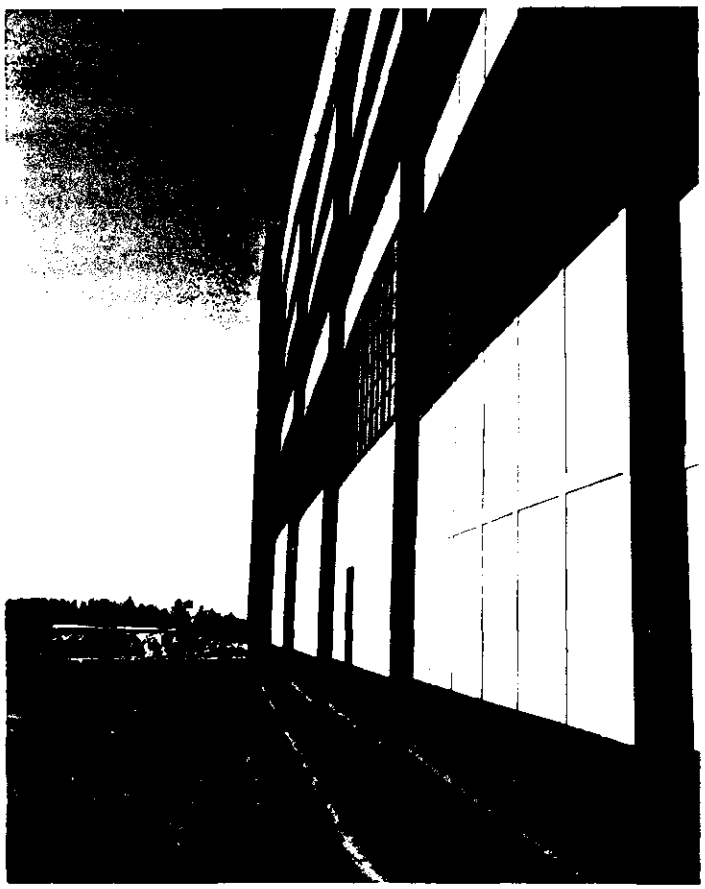


Arch Hangar under construction, view facing southeast, circa 1948. Photograph located at AFBCA, Loring AFB, Maine.

Arch Hangar under construction, circa 1948. Photograph located at AFBCA, Loring AFB, Maine.

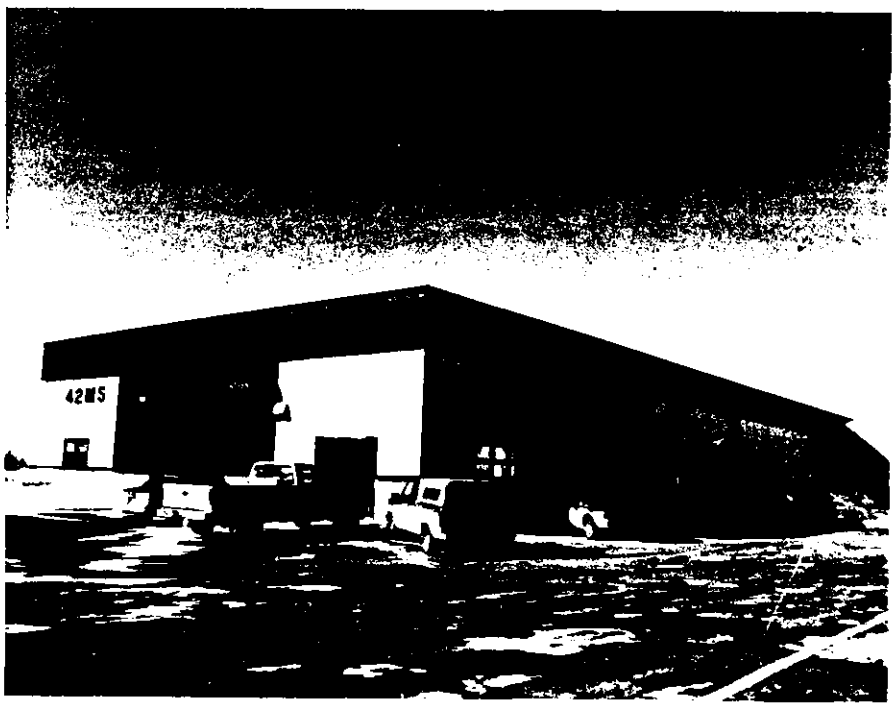


Arch Hangar before alteration of eastern elevation, facing northwest, date unknown. Photograph located at AFBCA, Loring AFB, Maine.



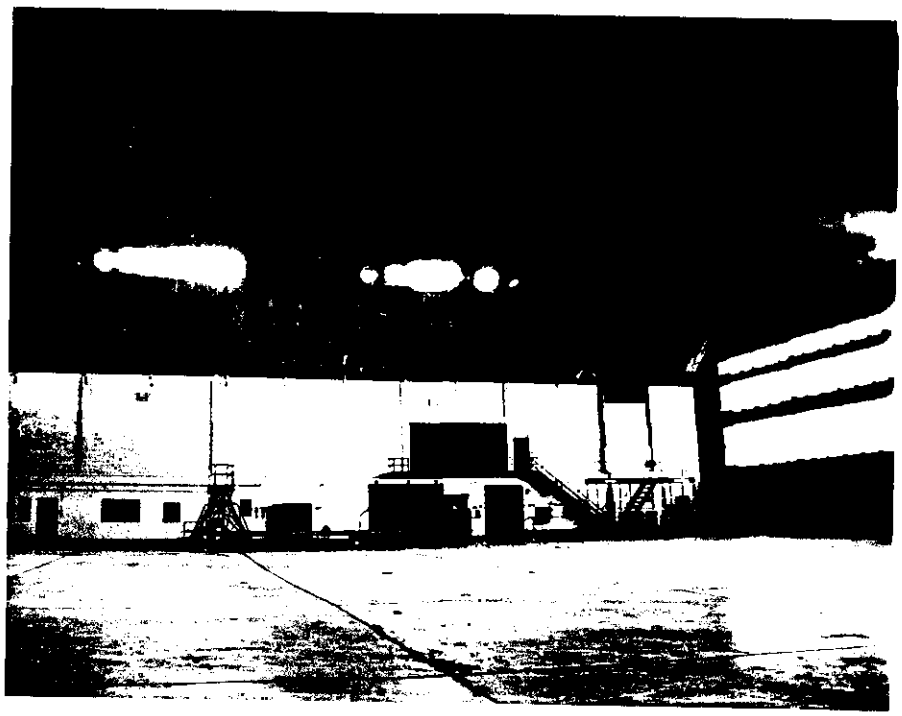
View of detail of hangar doors on the south side of Arch Hangar, facing west.

Photograph date: February 1994. Photograph location: AFBCA, Loring AFB, Maine.

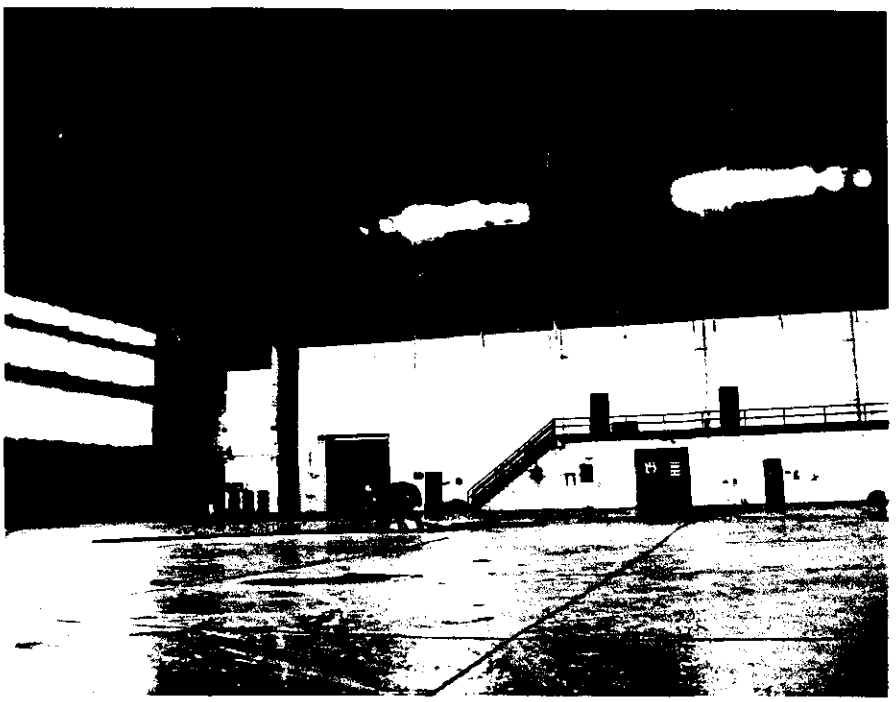


View of Arch Hangar addition (Building 8251), lateral view, facing northwest, with storage shed at right.

Photograph date: March 1994. Photograph location: AFBCA, Loring AFB, Maine.



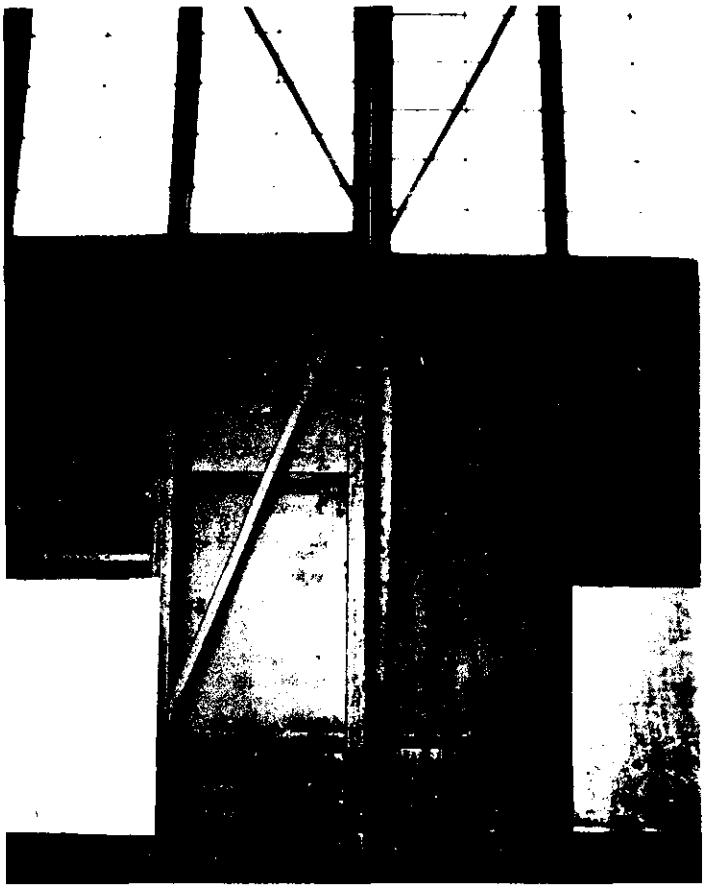
Interior view of Arch Hangar, looking west.
Photograph date: February 1994. Photograph location: AFBCA, Loring AFB, Maine.



Interior view of Arch Hangar, looking northeast.

Photograph date: February 1994. Photograph location: AFBCA, Loring AFB, Maine.

Interior view of interior shop addition of Arch Hangar, looking southwest.
Photograph date: February 1994. Photograph location: AFBCA, Loring AFB, Maine.



Interior view of sliding hangar doors, center pair, facing north.

Photograph date: February 1994. Photograph location: AFBCA, Loring AFB, Maine.